苏 州 大 学 实 验 报 告

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课程名称		机器学习课程实践				成绩	
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实 验 名 称　　　　机器学习综合实践实验四：决策树

一. 实验目的

　　本实验旨在通过在泰坦尼克号数据集上构建决策树分类模型，深入理解决策树的基本原理及其参数设置对模型性能的影响。通过对比 CART（基尼指数） 与 ID3（信息增益） 两种划分方式，掌握决策树的生长机制和预测过程。同时，结合 max_depth、min_samples_split、min_samples_leaf 等超参数的实验，直观感受欠拟合与过拟合的表现，并理解剪枝在防止模型过拟合、提高泛化能力中的作用。
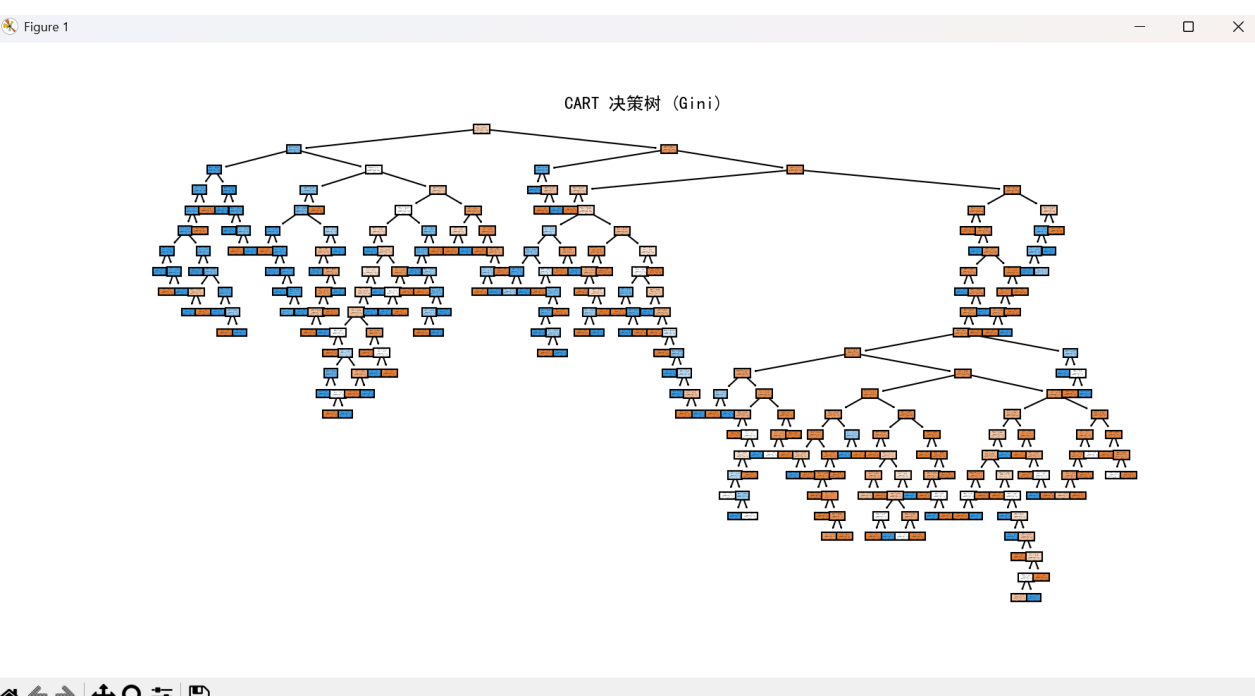
二. 实验内容

在泰坦尼克数据集上完成：

　　a. 使用 ID3 和 CART 的决策树分类器预测乘客生还与否；

　　b. 可视化决策树,打印出决策准则；

　　c. 输出决策树的准确率；

三. 实验步骤和结果

1. 利用最简单的方法进行实验，划分训练集和测试集（4:1）。直接调用 CART 的 "gini" 模型进行决策树的构建。ID3 用的是 "entropy"。此时并未考虑任何优化，也没有设置树的最大深度。任由其自行学习。

最终决策树级决策准则如下：

CART 方法：


```
CART 决策规则：
|--- Sex <= 0.50
|   |--- Pclass <= 2.50
```

教务处制

```
|    |    |--- Fare <= 28.86
|    |    |    |--- Age <= 56.00
|    |    |    |    |--- Fare <= 28.23
|    |    |    |    |    |--- SibSp <= 0.50
|    |    |    |    |    |    |--- Age <= 37.00
|    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |--- Age > 37.00
|    |    |    |    |    |    |    |--- Age <= 39.00
|    |    |    |    |    |    |    |    |--- class: 0
|    |    |    |    |    |    |    |--- Age > 39.00
|    |    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |--- SibSp > 0.50
|    |    |    |    |    |    |--- Age <= 25.00
|    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |--- Age > 25.00
|    |    |    |    |    |    |    |--- Age <= 27.50
|    |    |    |    |    |    |    |    |--- Fare <= 17.43
|    |    |    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |    |    |--- Fare > 17.43
|    |    |    |    |    |    |    |    |    |--- class: 0
|    |    |    |    |    |    |    |--- Age > 27.50
|    |    |    |    |    |    |    |    |--- Age <= 43.00
|    |    |    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |    |    |--- Age > 43.00
|    |    |    |    |    |    |    |    |    |--- Age <= 44.50
|    |    |    |    |    |    |    |    |    |    |--- class: 0
|    |    |    |    |    |    |    |    |    |--- Age > 44.50
|    |    |    |    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |--- Fare > 28.23
|    |    |    |    |    |--- class: 0
|    |    |    |--- Age > 56.00
|    |    |    |    |--- class: 0
|    |    |--- Fare > 28.86
|    |    |    |--- Parch <= 1.50
|    |    |    |    |--- class: 1
|    |    |    |--- Parch > 1.50
|    |    |    |    |--- Fare <= 135.78
|    |    |    |    |    |--- class: 1
|    |    |    |    |--- Fare > 135.78
|    |    |    |    |    |--- Fare <= 158.21
|    |    |    |    |    |    |--- class: 0
|    |    |    |    |    |--- Fare > 158.21
|    |    |    |    |    |    |--- class: 1
|    |--- Pclass > 2.50
|    |    |--- Embarked <= 1.50
```

教务处制

```
|   |   |   |   |--- Age <= 29.75
|   |   |   |   |   |--- Fare <= 8.08
|   |   |   |   |   |   |--- Fare <= 6.99
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Fare >  6.99
|   |   |   |   |   |   |   |--- Age <= 25.00
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Age >  25.00
|   |   |   |   |   |   |   |   |--- Fare <= 7.74
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Fare >  7.74
|   |   |   |   |   |   |   |   |   |--- Fare <= 7.79
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Fare >  7.79
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  8.08
|   |   |   |   |   |--- Fare <= 15.37
|   |   |   |   |   |   |--- Age <= 6.50
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Age >  6.50
|   |   |   |   |   |   |   |--- Age <= 28.50
|   |   |   |   |   |   |   |   |--- Age <= 16.00
|   |   |   |   |   |   |   |   |   |--- Age <= 14.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Age >  14.75
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  16.00
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Age >  28.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Fare >  15.37
|   |   |   |   |   |   |--- class: 1
|   |   |   |--- Age >  29.75
|   |   |   |   |--- class: 0
|   |   |--- Embarked >  1.50
|   |   |   |--- Fare <= 17.25
|   |   |   |   |--- Fare <= 10.82
|   |   |   |   |   |--- Fare <= 7.52
|   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Fare >  7.52
|   |   |   |   |   |   |--- Fare <= 9.71
|   |   |   |   |   |   |   |--- Parch <= 0.50
|   |   |   |   |   |   |   |   |--- Age <= 54.00
|   |   |   |   |   |   |   |   |   |--- Age <= 27.00
|   |   |   |   |   |   |   |   |   |   |--- Age <= 18.50
```

教务处制

```
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Age >  18.50
|   |   |   |   |   |   |   |   |   |   |  |--- truncated branch of depth 4
|   |   |   |   |   |   |   |   |   |--- Age >  27.00
|   |   |   |   |   |   |   |   |   |  |--- Fare <= 8.67
|   |   |   |   |   |   |   |   |   |  |  |--- class: 0
|   |   |   |   |   |   |   |   |   |  |--- Fare >  8.67
|   |   |   |   |   |   |   |   |   |  |  |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |--- Age >  54.00
|   |   |   |   |   |   |   |   |  |--- class: 1
|   |   |   |   |   |   |   |--- Parch >  0.50
|   |   |   |   |   |   |   |  |--- class: 1
|   |   |   |   |   |   |--- Fare >  9.71
|   |   |   |   |   |   |  |--- Age <= 19.00
|   |   |   |   |   |   |  |  |--- Fare <= 10.15
|   |   |   |   |   |   |  |  |  |--- class: 1
|   |   |   |   |   |   |  |  |--- Fare >  10.15
|   |   |   |   |   |   |  |  |  |--- class: 0
|   |   |   |   |   |   |  |--- Age >  19.00
|   |   |   |   |   |   |  |  |--- class: 0
|   |   |   |--- Fare >  10.82
|   |   |   |  |--- Age <= 40.00
|   |   |   |  |  |--- Fare <= 13.44
|   |   |   |  |  |  |--- class: 1
|   |   |   |  |  |--- Fare >  13.44
|   |   |   |  |  |  |--- Fare <= 15.12
|   |   |   |  |  |  |  |--- class: 0
|   |   |   |  |  |  |--- Fare >  15.12
|   |   |   |  |  |  |  |--- Parch <= 0.50
|   |   |   |  |  |  |  |  |--- Age <= 27.00
|   |   |   |  |  |  |  |  |  |--- class: 0
|   |   |   |  |  |  |  |  |--- Age >  27.00
|   |   |   |  |  |  |  |  |  |--- class: 1
|   |   |   |  |  |  |  |--- Parch >  0.50
|   |   |   |  |  |  |  |  |--- class: 1
|   |   |   |  |--- Age >  40.00
|   |   |   |  |  |--- class: 0
|   |   |--- Fare >  17.25
|   |   |  |--- Age <= 5.50
|   |   |  |  |--- Age <= 3.50
|   |   |  |  |  |--- class: 0
|   |   |  |  |--- Age >  3.50
|   |   |  |  |  |--- class: 1
|   |   |  |--- Age >  5.50
|   |   |  |  |--- Age <= 30.00
```

教务处制

```
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Age >  30.00
|   |   |   |   |   |   |--- Age <= 38.50
|   |   |   |   |   |   |   |--- Parch <= 0.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Parch >  0.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Age >  38.50
|   |   |   |   |   |   |   |--- class: 0
|--- Sex >  0.50
|   |--- Age <= 3.50
|   |   |--- SibSp <= 2.50
|   |   |   |--- class: 1
|   |   |--- SibSp >  2.50
|   |   |   |--- Parch <= 1.50
|   |   |   |   |--- class: 0
|   |   |   |--- Parch >  1.50
|   |   |   |   |--- class: 1
|   |--- Age >  3.50
|   |   |--- Pclass <= 1.50
|   |   |   |--- Fare <= 26.14
|   |   |   |   |--- class: 0
|   |   |   |--- Fare >  26.14
|   |   |   |   |--- Fare <= 30.60
|   |   |   |   |   |--- Age <= 54.00
|   |   |   |   |   |   |--- Fare <= 27.14
|   |   |   |   |   |   |   |--- Age <= 31.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Age >  31.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Fare >  27.14
|   |   |   |   |   |   |   |--- Fare <= 29.10
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Fare >  29.10
|   |   |   |   |   |   |   |   |--- Parch <= 0.50
|   |   |   |   |   |   |   |   |   |--- Age <= 28.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  28.50
|   |   |   |   |   |   |   |   |   |   |--- Fare <= 30.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Fare >  30.25
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Parch >  0.50
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Age >  54.00
```
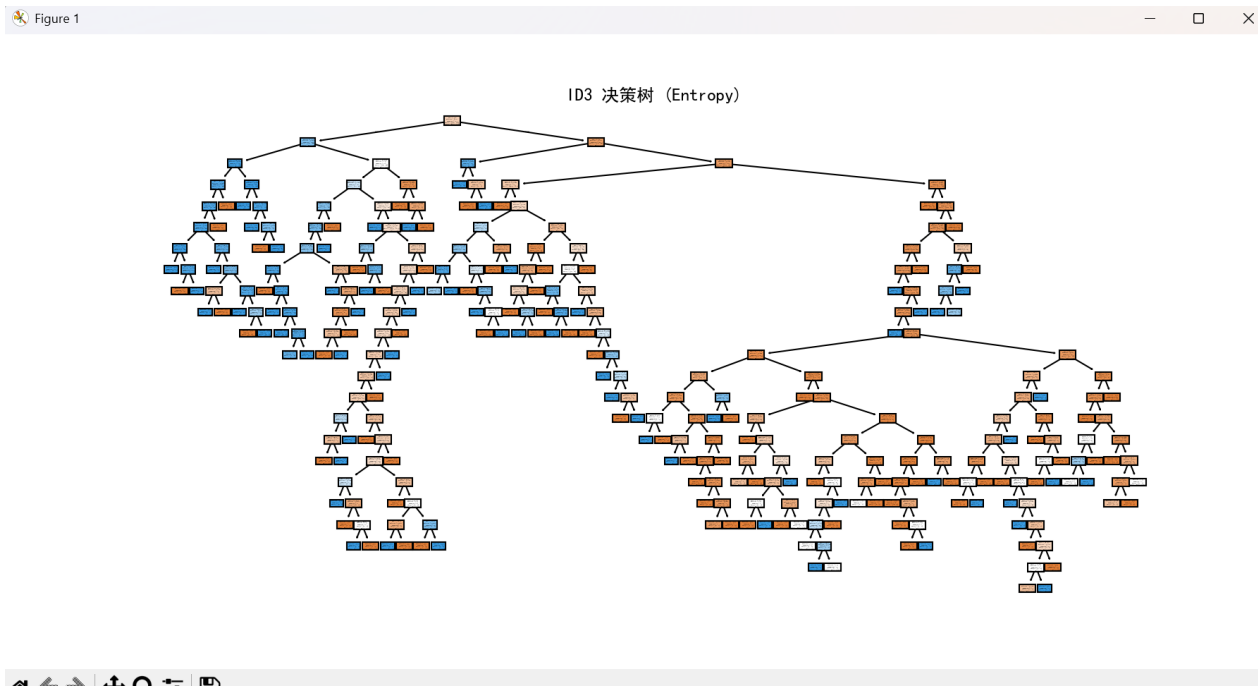
教务处制

```
|   |   |   |   |   |   |   |--- Age <= 72.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Age >  72.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Fare >  30.60
|   |   |   |   |   |   |--- Fare <= 52.28
|   |   |   |   |   |   |   |--- Embarked <= 1.00
|   |   |   |   |   |   |   |   |--- Age <= 38.00
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Age >  38.00
|   |   |   |   |   |   |   |   |   |--- Age <= 63.50
|   |   |   |   |   |   |   |   |   |   |--- Fare <= 30.85
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Fare >  30.85
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  63.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Embarked >  1.00
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Fare >  52.28
|   |   |   |   |   |   |   |--- Age <= 50.50
|   |   |   |   |   |   |   |   |--- Fare <= 77.01
|   |   |   |   |   |   |   |   |   |--- Age <= 21.00
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Age >  21.00
|   |   |   |   |   |   |   |   |   |   |--- Age <= 49.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Age >  49.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Fare >  77.01
|   |   |   |   |   |   |   |   |   |--- Age <= 17.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  17.50
|   |   |   |   |   |   |   |   |   |   |--- Age <= 31.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Age >  31.50
|   |   |   |   |   |   |   |   |   |   |   |--- Fare <= 84.15
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |   |--- Fare >  84.15
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |   |--- Age >  50.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |--- Pclass >  1.50
|   |   |   |--- Fare <= 51.70
|   |   |   |   |--- Fare <= 7.13
```

教务处制

```
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- Fare >  7.13
|   |   |   |   |   |--- Fare <= 7.18
|   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Fare >  7.18
|   |   |   |   |   |   |--- Fare <= 23.35
|   |   |   |   |   |   |   |--- Age <= 13.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Age >  13.50
|   |   |   |   |   |   |   |   |--- Fare <= 22.89
|   |   |   |   |   |   |   |   |   |--- Age <= 45.25
|   |   |   |   |   |   |   |   |   |   |--- Age <= 43.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 13
|   |   |   |   |   |   |   |   |   |   |--- Age >  43.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |--- Age >  45.25
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Fare >  22.89
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Fare >  23.35
|   |   |   |   |   |   |   |--- Parch <= 0.50
|   |   |   |   |   |   |   |   |--- Age <= 32.25
|   |   |   |   |   |   |   |   |   |--- Age <= 31.00
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Age >  31.00
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  32.25
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Parch >  0.50
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |--- Fare >  51.70
|   |   |   |   |--- Fare <= 63.02
|   |   |   |   |   |--- Age <= 30.00
|   |   |   |   |   |   |--- Age <= 27.00
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Age >  27.00
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Age >  30.00
|   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  63.02
|   |   |   |   |   |--- class: 0
```

结果：

CART 准确率：0.8324022346368715

教务处制

ID3 决策树：

ID3 决策规则:

```
|--- Sex <= 0.50
|    |--- Pclass <= 2.50
|    |    |--- Fare <= 28.86
|    |    |    |--- Age <= 56.00
|    |    |    |    |--- Fare <= 28.23
|    |    |    |    |    |--- SibSp <= 0.50
|    |    |    |    |    |    |--- Age <= 37.00
|    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |--- Age >  37.00
|    |    |    |    |    |    |    |--- Age <= 39.00
|    |    |    |    |    |    |    |    |--- class: 0
|    |    |    |    |    |    |    |--- Age >  39.00
|    |    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |--- SibSp >  0.50
|    |    |    |    |    |    |--- Age <= 25.00
|    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |--- Age >  25.00
|    |    |    |    |    |    |    |--- Age <= 27.50
|    |    |    |    |    |    |    |    |--- Fare <= 17.43
|    |    |    |    |    |    |    |    |    |--- class: 1
|    |    |    |    |    |    |    |    |--- Fare >  17.43
|    |    |    |    |    |    |    |    |    |--- class: 0
```

教务处制

```
|   |   |   |   |   |   |   |   |--- Age >  27.50
|   |   |   |   |   |   |   |   |   |--- Age <= 43.00
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  43.00
|   |   |   |   |   |   |   |   |   |   |--- Age <= 44.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Age >  44.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  28.23
|   |   |   |   |   |--- class: 0
|   |   |   |--- Age >  56.00
|   |   |   |   |--- class: 0
|   |   |--- Fare >  28.86
|   |   |   |--- Parch <= 1.50
|   |   |   |   |--- class: 1
|   |   |   |--- Parch >  1.50
|   |   |   |   |--- Fare <= 135.78
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  135.78
|   |   |   |   |   |--- Fare <= 158.21
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Fare >  158.21
|   |   |   |   |   |   |--- class: 1
|   |--- Pclass >  2.50
|   |   |--- Fare <= 24.81
|   |   |   |--- Embarked <= 1.50
|   |   |   |   |--- Age <= 29.75
|   |   |   |   |   |--- Fare <= 15.37
|   |   |   |   |   |   |--- Fare <= 8.08
|   |   |   |   |   |   |   |--- Fare <= 6.99
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Fare >  6.99
|   |   |   |   |   |   |   |   |--- Age <= 25.00
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  25.00
|   |   |   |   |   |   |   |   |   |--- Fare <= 7.74
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Fare >  7.74
|   |   |   |   |   |   |   |   |   |   |--- Fare <= 7.79
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Fare >  7.79
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Fare >  8.08
|   |   |   |   |   |   |   |--- Age <= 6.50
|   |   |   |   |   |   |   |   |--- class: 1
```

教务处制

```
|   |   |   |   |   |   |   |   |--- Age >  6.50
|   |   |   |   |   |   |   |   |   |--- Age <= 28.50
|   |   |   |   |   |   |   |   |   |   |--- Age <= 16.00
|   |   |   |   |   |   |   |   |   |   |   |--- Age <= 14.75
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |   |--- Age >  14.75
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- Age >  16.00
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Age >  28.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Fare >  15.37
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Age >  29.75
|   |   |   |   |   |--- class: 0
|   |   |   |--- Embarked >  1.50
|   |   |   |   |--- Fare <= 7.52
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  7.52
|   |   |   |   |   |--- Age <= 6.50
|   |   |   |   |   |   |--- Fare <= 10.80
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Fare >  10.80
|   |   |   |   |   |   |   |--- SibSp <= 2.00
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- SibSp >  2.00
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Age >  6.50
|   |   |   |   |   |   |--- Fare <= 20.80
|   |   |   |   |   |   |   |--- SibSp <= 2.00
|   |   |   |   |   |   |   |   |--- Age <= 55.00
|   |   |   |   |   |   |   |   |   |--- Age <= 34.00
|   |   |   |   |   |   |   |   |   |   |--- Parch <= 1.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 10
|   |   |   |   |   |   |   |   |   |   |--- Parch >  1.50
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  34.00
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Age >  55.00
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- SibSp >  2.00
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Fare >  20.80
|   |   |   |   |   |   |   |--- class: 0
|   |   |--- Fare >  24.81
```
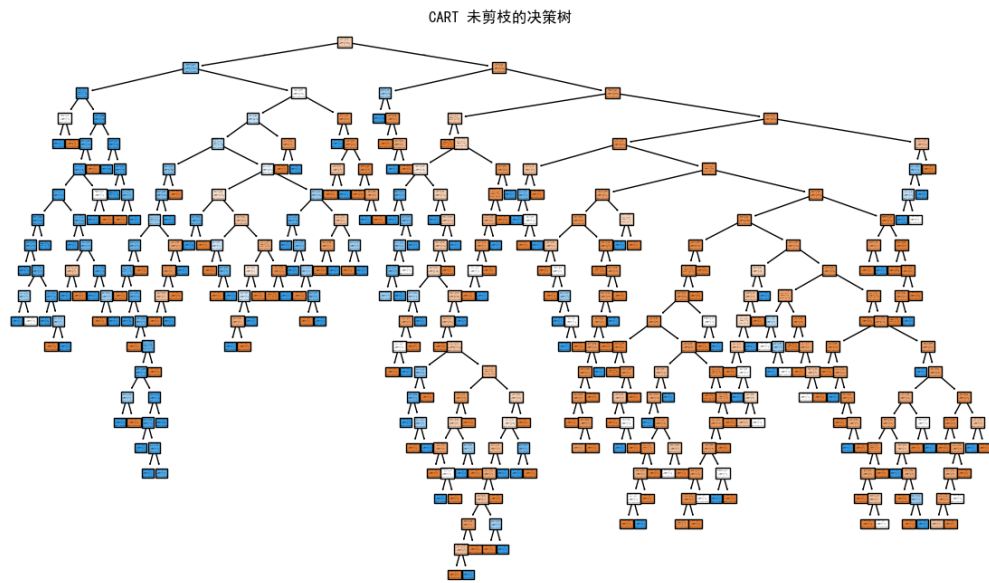
教务处制

```
|   |   |   |--- Fare <= 31.33
|   |   |   |   |--- class: 0
|   |   |   |--- Fare >  31.33
|   |   |   |   |--- Fare <= 32.88
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  32.88
|   |   |   |   |   |--- class: 0
|--- Sex >  0.50
|   |--- Age <= 3.50
|   |   |--- SibSp <= 2.50
|   |   |   |--- class: 1
|   |   |--- SibSp >  2.50
|   |   |   |--- Parch <= 1.50
|   |   |   |   |--- class: 0
|   |   |   |--- Parch >  1.50
|   |   |   |   |--- class: 1
|   |--- Age >  3.50
|   |   |--- Pclass <= 1.50
|   |   |   |--- Fare <= 26.14
|   |   |   |   |--- class: 0
|   |   |   |--- Fare >  26.14
|   |   |   |   |--- Fare <= 30.60
|   |   |   |   |   |--- Age <= 54.00
|   |   |   |   |   |   |--- Fare <= 27.14
|   |   |   |   |   |   |   |--- Age <= 31.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Age >  31.50
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- Fare >  27.14
|   |   |   |   |   |   |   |--- Fare <= 29.10
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Fare >  29.10
|   |   |   |   |   |   |   |   |--- Age <= 28.50
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  28.50
|   |   |   |   |   |   |   |   |   |--- Fare <= 30.25
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Fare >  30.25
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- Age >  54.00
|   |   |   |   |   |   |--- Age <= 72.50
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Age >  72.50
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- Fare >  30.60
```
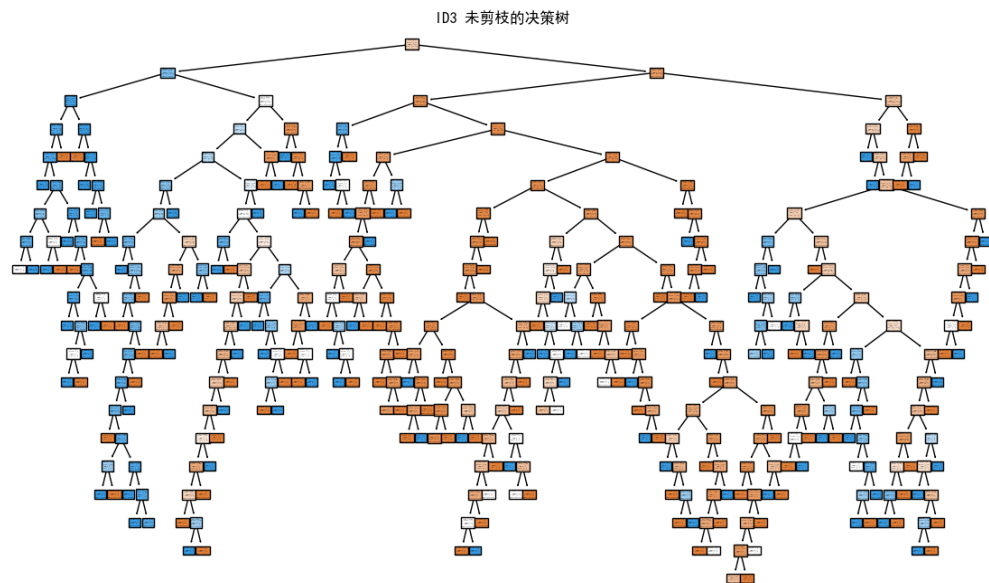
教务处制

```
|   |   |   |   |   |--- Fare <= 52.28
|   |   |   |   |   |   |--- Fare <= 37.00
|   |   |   |   |   |   |   |--- Embarked <= 1.00
|   |   |   |   |   |   |   |   |--- Fare <= 30.85
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Fare >  30.85
|   |   |   |   |   |   |   |   |   |--- Age <= 63.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  63.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Embarked >  1.00
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Fare >  37.00
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Fare >  52.28
|   |   |   |   |   |   |--- Age <= 50.50
|   |   |   |   |   |   |   |--- Fare <= 77.01
|   |   |   |   |   |   |   |   |--- Age <= 21.00
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- Age >  21.00
|   |   |   |   |   |   |   |   |   |--- Age <= 49.50
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  49.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- Fare >  77.01
|   |   |   |   |   |   |   |   |--- Age <= 17.50
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  17.50
|   |   |   |   |   |   |   |   |   |--- Age <= 31.50
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- Age >  31.50
|   |   |   |   |   |   |   |   |   |   |--- Fare <= 84.15
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- Fare >  84.15
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |--- Age >  50.50
|   |   |   |   |   |   |   |--- class: 0
|   |   |--- Pclass >  1.50
|   |   |   |--- Fare <= 7.13
|   |   |   |   |--- class: 0
|   |   |   |--- Fare >  7.13
|   |   |   |   |--- Age <= 45.25
|   |   |   |   |   |--- Fare <= 51.70
|   |   |   |   |   |   |--- Fare <= 26.12
|   |   |   |   |   |   |   |--- Age <= 13.50
```

教务处制

```
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  13.50
|   |   |   |   |   |   |   |   |--- Age <= 44.50
|   |   |   |   |   |   |   |   |   |--- Fare <= 7.18
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Fare >  7.18
|   |   |   |   |   |   |   |   |   |   |--- Age <= 28.75
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 11
|   |   |   |   |   |   |   |   |   |   |--- Age >  28.75
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 12
|   |   |   |   |   |   |   |   |--- Age >  44.50
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Fare >  26.12
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- Fare >  51.70
|   |   |   |   |   |   |   |--- Fare <= 63.02
|   |   |   |   |   |   |   |   |--- Age <= 30.00
|   |   |   |   |   |   |   |   |   |--- Age <= 27.00
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- Age >  27.00
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- Age >  30.00
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- Fare >  63.02
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- Age >  45.25
|   |   |   |   |   |--- class: 0
```

结果：

ID3 准确率：0.8100558659217877

【自我分析】

　　虽然不做任何约束和剪枝时模型的准确率很高,但是我认为这并不是 800 多条数据该有的准确度,或者说这样简单的划分数据集训练出来的结果还是有偶然性的。用这些数据检测出来的准确率可能很高,但是如果换其他数据可能效果就会比较差,这也就是"过拟合"现象。

　　于是学习了一种能够一定程度上能改善这种现象的数据集划分方法——交叉验证。原理是将整体数据集划分为五块（其他块数也行）,然后循环用其中的一块作为测试集,其余作为训练集。这样一来,所有块都会有机会作为训练集和测试集。这种方法能大大减小偶然性。

结果如下：（由于决策准则太长,此处就不加上了）

CART:

教务处制

CART 未剪枝的决策树

CART 交叉验证准确率 (未剪枝): 0.7801 (±0.0320)

ID3：

ID3 未剪枝的决策树

ID3 交叉验证准确率 (未剪枝): 0.7789 (±0.0238)

　　发现此时的精确度确实略有下降，恰好印证了我之前的想法。接下来进一步尝试通过剪枝来进行优化。

　　综合考虑下决定采用"后剪枝"的方法。因为如果预剪枝的话只是提前限制了它的深度，很难掌控一个好的度。于是采用代价复杂度剪枝（Cost Complexity Pruning）方法，通过调节 ccp_alpha 参数去除对预测贡献较小的分支。实验结果显示，剪枝前后模型在准确率上差异不大，但树的深度和叶子数明显减少，结构更加简洁，解释性和泛化能力得到提升。
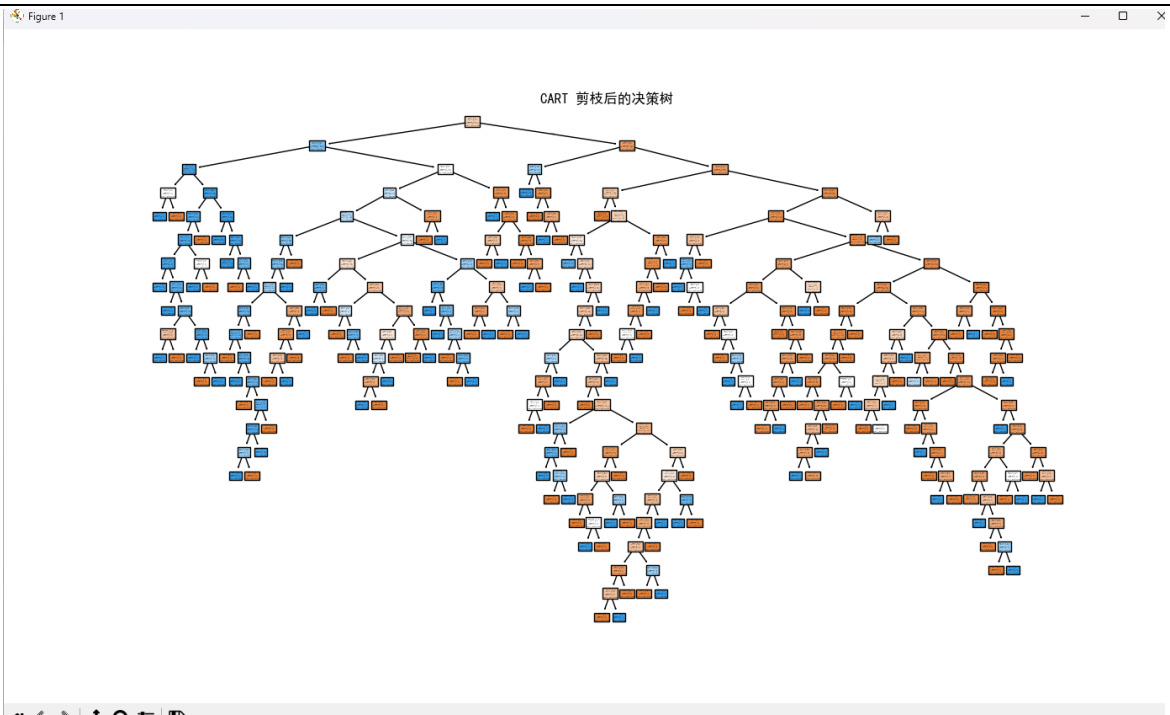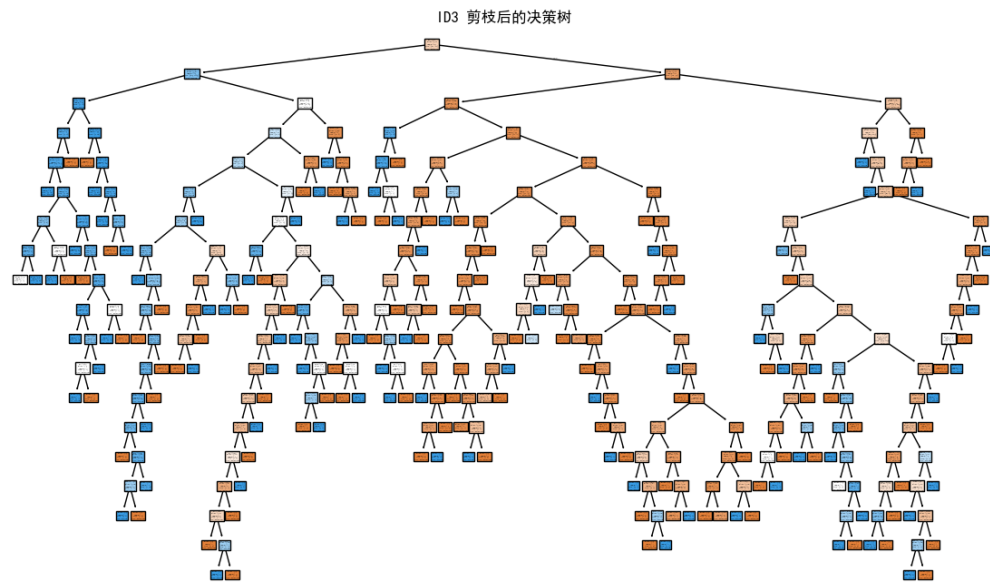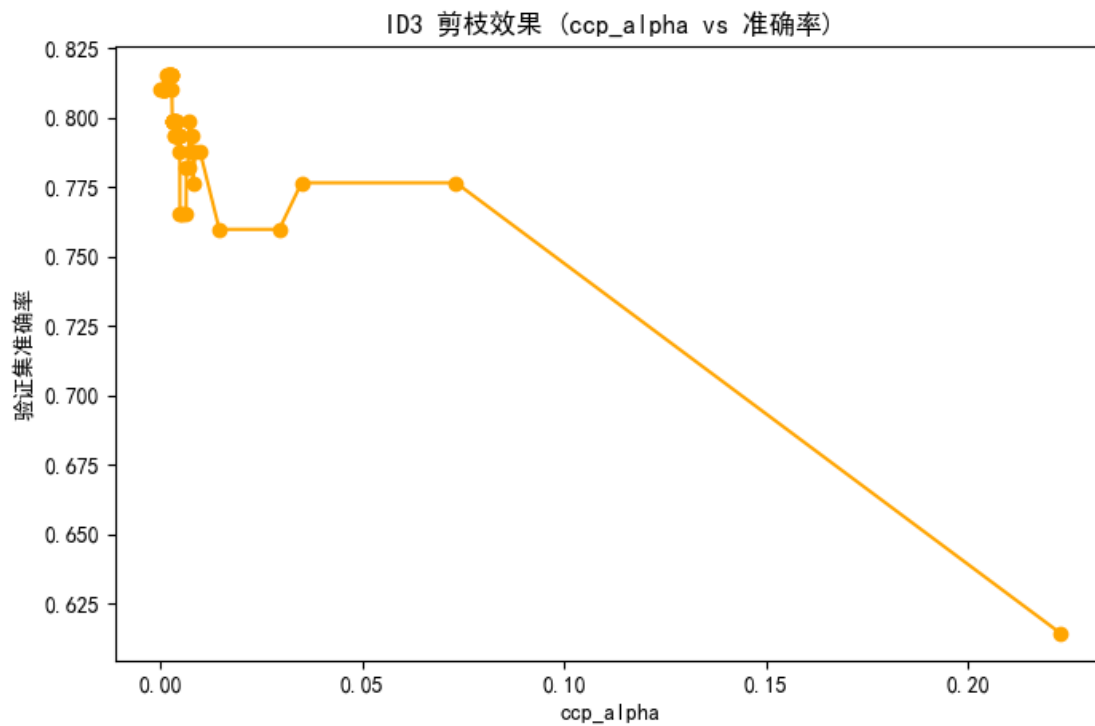
结果如下：

教务处制

Figure 1 — □ ×

CART 剪枝后的决策树

Figure 1 — □

CART 剪枝效果（ccp_alpha vs 准确率）

ccp_alpha

验证集准确率

教务处制

ID3 剪枝后的决策树

ID3 剪枝效果（ccp_alpha vs 准确率）

精准度也有了提高：

教务处制

```
CART 交叉验证准确率 （未剪枝）: 0.7801 (±0.0320)
CART 最佳剪枝参数 ccp_alpha: 0.000734167517875383
CART 验证集准确率 （剪枝后）: 0.8379888268156425

ID3 交叉验证准确率 （未剪枝）: 0.7789 (±0.0238)
ID3 最佳剪枝参数 ccp_alpha: 0.0014486378799917164
ID3 验证集准确率 （剪枝后）: 0.8156424581005587
```

在 Titanic 数据集上，CART 与 ID3 在未剪枝时都能获得较高的准确率，但存在树结构过深、节点过多的问题。经过后剪枝处理后，两种算法的测试集准确率与未剪枝基本持平，而决策树的深度和叶子数有所减少。其中，CART 在剪枝后依然保持较优的预测性能，结构更为简洁；ID3 剪枝后**准确率略有下降，但模型复杂度显著降低。**整体来看，剪枝能够在保持性能稳定的同时提升模型的可解释性与泛化能力。

四. 实验总结

本实验基于 Titanic 数据集，分别构建了 CART（基尼指数）和 ID3（信息增益）两种决策树分类器，并结合交叉验证和后剪枝方法对模型性能进行了评估与优化。实验结果显示，未剪枝的决策树能够较好地拟合训练数据，在测试集上也取得了较高的准确率，但树的深度较大、叶子节点较多，存在一定的过拟合风险。

在采用代价复杂度剪枝（ccp_alpha）后，两类决策树在测试集上的准确率与未剪枝时基本持平，但模型结构显著简化，深度和叶子数均有所下降，规则更清晰，解释性和泛化能力得到提升。从对比结果看，CART 在准确率和稳定性上整体优于 ID3，而 ID3 剪枝后虽然准确率略有下降，但模型复杂度明显降低，更有助于理解模型的决策逻辑。

综上，本实验验证了决策树在分类任务中的有效性，同时说明了剪枝在防止过拟合、提升泛化能力和模型可解释性方面的重要作用。CART 更适合在注重性能的场景中应用，而 ID3 在教学演示和模型可解释性方面具有一定优势，为后续的模型选择和改进提供了参考。

教务处制